CHAPTER 1

INTRODUCTION

1.1 CO_2 Laser Cutting Background and Applications

The first laser cut [1] was produced at The Welding Institute, Cambridge, UK in 1969 but the first industrial use of CO_2 lasers was the cutting of plywood dye boards for the packaging industry in 1971. In recent years CO_2 Laser Cutting is being increasingly used in the aircraft and automotive industries to cut, trim, drill holes and weld sheet metal parts. Compared with other conventional mechanical processes, laser cutting removes little material, involves highly localized heat input to the workpiece, minimizes distortion, and offers no tool wear. A substantial amount of work has been performed on the laser gas cutting, demonstrating its feasibility [2-11]. The parameters being investigated include laser power, frequency, duty cycle, standoff distance, cutting speed, material thickness, and gas assist pressure.

1.2 Brief Review of CO_2 Laser Machining Process

In the laser through cutting process, a kerf is created through relative motion between the laser beam and the workpiece surface. This process allows intricate two-dimensional shapes to be cut on a flat workpiece. The physical mechanisms for material removal and energy losses depend on the incoming laser beam energy which is balanced by the conduction heat, energy for melting or vaporization of material and heat losses to the environment. However, due to the relative beam/workpiece movement, the erosion front formed in front of the laser beam and the temperature

field in the workpiece is stationary with respect to a coordinate system moving with the laser beam. Therefore, laser cutting can be considered a steady-state thermal process. Since the workpiece thickness is equal to the depth of cut, conduction heat occurs in the plane of the workpiece. The temperature inside the workpiece is dependent on the distance to the erosion front and is independent of time.

When material is removed through melting, a molten layer forms at the erosion front. The accumulated molten material can be expelled from the bottom of the kerf with the aid of a coaxial gas jet.

Because of the unique characteristics of the laser beam, laser cutting has several advantages:

- For most industrial materials with thicknesses up to 10mm, laser cutting produces a significantly higher material removal rate than mechanical cutting or shearing.
- Laser cutting produces kerf widths which are narrower than those achievable with mechanical cutting. This results in less material wasted during cutting operations.
- When coupled with a multi-axis position control system for the workpiece or beam, shapes can also be cut from curved workpieces. Conventional mechanical methods can only cut flat workpieces effectively. Lasers can be applied to trimming operations to remove flash and burrs from curved parts.
- For cutting of fibrous material such as wood, paper, or composites, the laser beam vaporizes the volume of material to be removed, thereby eliminating

the residue and debris which remain after mechanical cutting. This reduces the need for solid waste collection and disposal and reduces the health hazard in the work environment.

The drawbacks of laser cutting in comparison to conventional methods are:

- Laser cutting effectiveness reduces as the workpiece thickness increases. Workpieces greater than 15mm in thickness generally cannot be cut effectively by modern industrial lasers.
- Laser cutting produces a tapered kerf shape, compared to the straight vertical kerf walls achievable by conventional methods. The kerf taper is a result of the divergence of the laser beam and becomes more pronounced as the workpiece thickness increases. The kerf taper can be reduced by adjusting the focal point of the laser beam to the interior of the workpiece instead of on the workpiece surface.

1.3 Objectives of the Study

In this project, the existing 8-tube FAF CW CO_2 laser system developed at the University of Malaya together with an existing XY control table will be utilized to study the cutting of sharp curvatures. A CO_2 laser cutting program with user-friendly graphical user interface will be developed to aid the research. A corner cutting algorithm will be developed next to suit the existing system in order to get an acceptable corner cutting results.